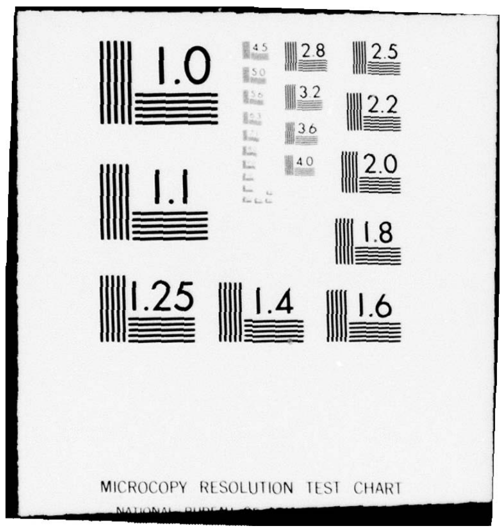
1.0
4.5
5.0
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2.5
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1.25
1.4
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MICROCOPY RESOLUTION TEST CHART

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14 PSU-IRL-SAR-78/2

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University Park, Pennsylvania 16802

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INTRODUCTION

This report is a statement of work currently in progress and is intended to meet contractural report requirements. Many of the topics discussed are part of M. S. and Ph.D. thesis programs, and great care should be taken in the use of this data. No part of the report should be quoted without the expressed permission of the authors.

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A. RESEARCH PROGRESS

1. Planetary Atmospheres

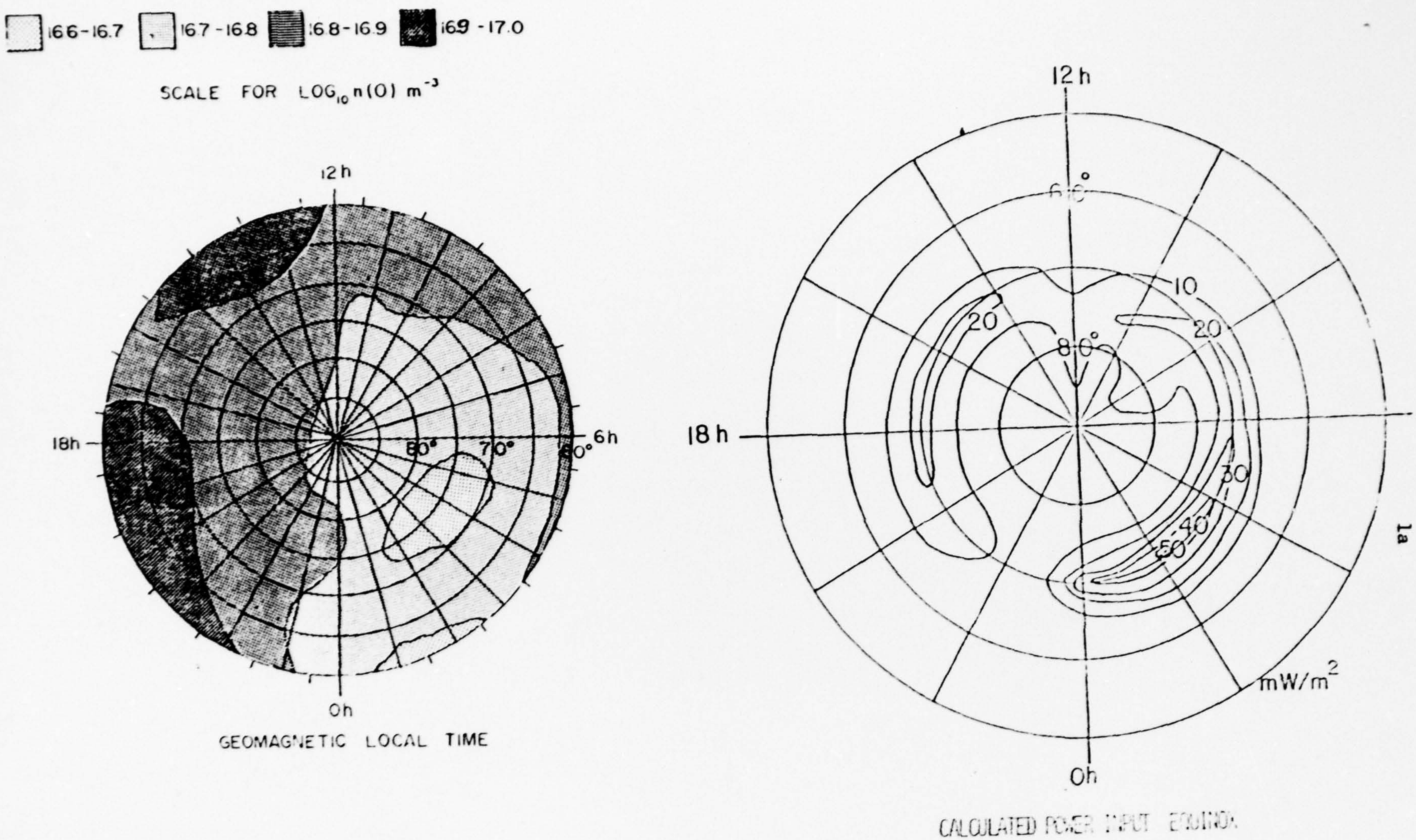
1.1 Energy Balance of the Polar Thermosphere - J. S. Nisbet, M. Griffis, C. H. Li, C. G. Stehle

Work has continued on an examination of the thermal balance of the polar thermosphere following the work of Nisbet and Glenar (1977) and Glenar, Nisbet, and Bleuler (1978). New models have been developed of the current deposition in the auroral zone by the Birkeland System. The new model taking into account the variation of the current system with the K_p index and the variation of the cusp current and its relation to the interplanetary magnetic field.

Figure 1 shows the variation of the electric field pattern calculated for two values of the z component of the interplanetary field. Such calculations are important because there have been continuing studies of the effect of sector crossings on weather in the troposphere Roberts and Olson (1973), Hines and Halevy (1975) and Wilcox (1976). Before attempts can be made to put the causative mechanisms on a quantitative basis it is necessary to calculate the effect of the sector crossings on the electric field pattern.

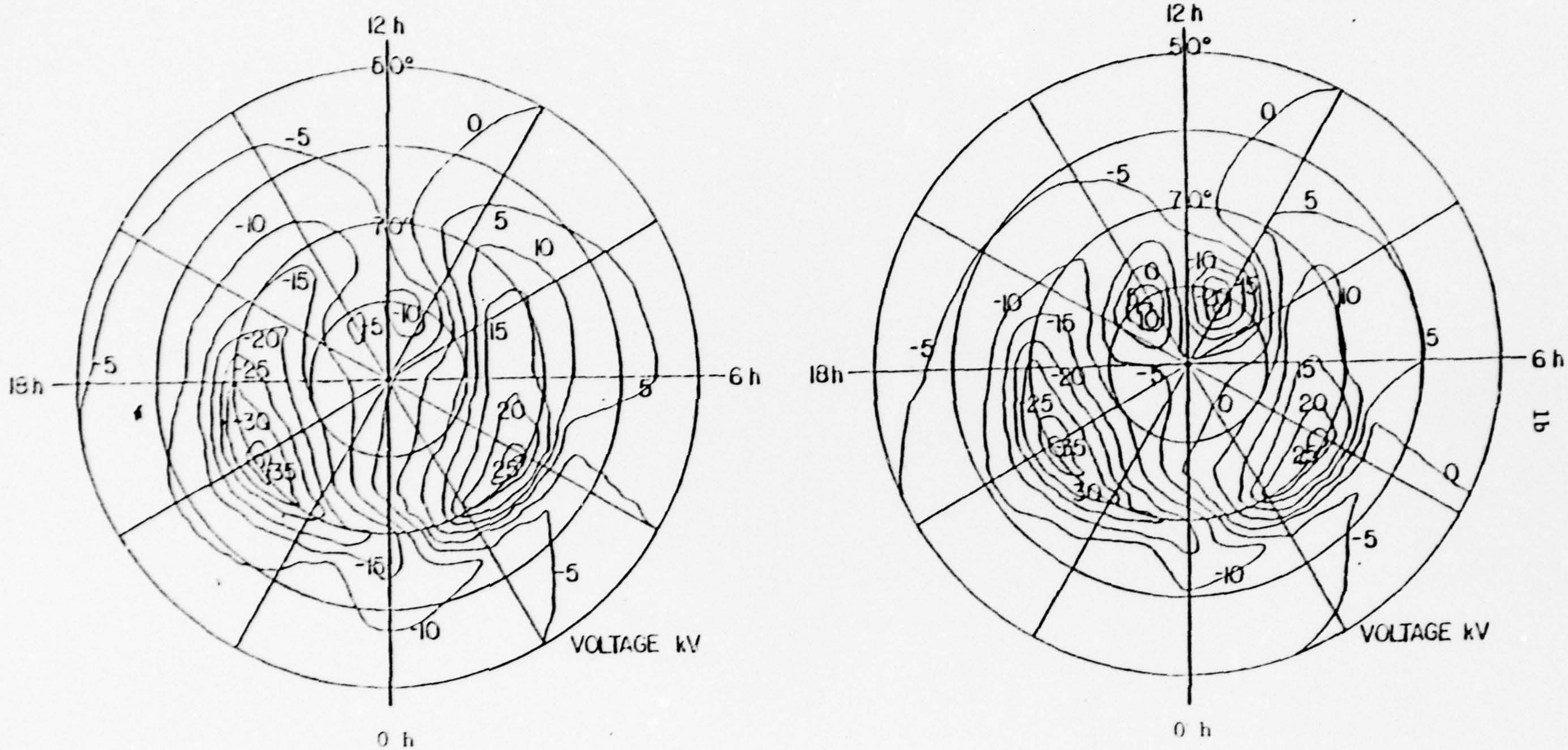
Figure 2 shows estimates made of the energy input from the Birkeland current system calculated for equinox conditions compared with new calculations by Carl Stehle of the atomic oxygen densities in the vicinity of 120 km calculated from AEC data. Such measurements are very sensitive to vertical fluxes, (Nisbet and Glenar, 1977). Regions of low density are well correlated with regions of large energy deposition.

Severe problems were encountered in the analysis of OGO 6 data with the Helium densities (Gardener 1977). While the atomic oxygen densities, molecular nitrogen densities and 630 nm airglow temperatures all appeared



16.6-16.7
16.7-16.8
16.8-16.9
16.9-17.0
SCALE FOR $LOG_{10}\,n(O)\ m^{-3}$
12h
18h
6h
0h
80°
70°
60°
GEOMAGNETIC LOCAL TIME
12h
18h
0h
60°
80°
10
20
20
30
40
50
mW/m^2
1a
CALCULATED POWER INPUT EQUINOX

Figure 1



(A) $B_Z = -2\gamma$

(B) $B_Z = +2\gamma$

VARIATION OF INTERPLANETARY MAGNETIC FIELDS

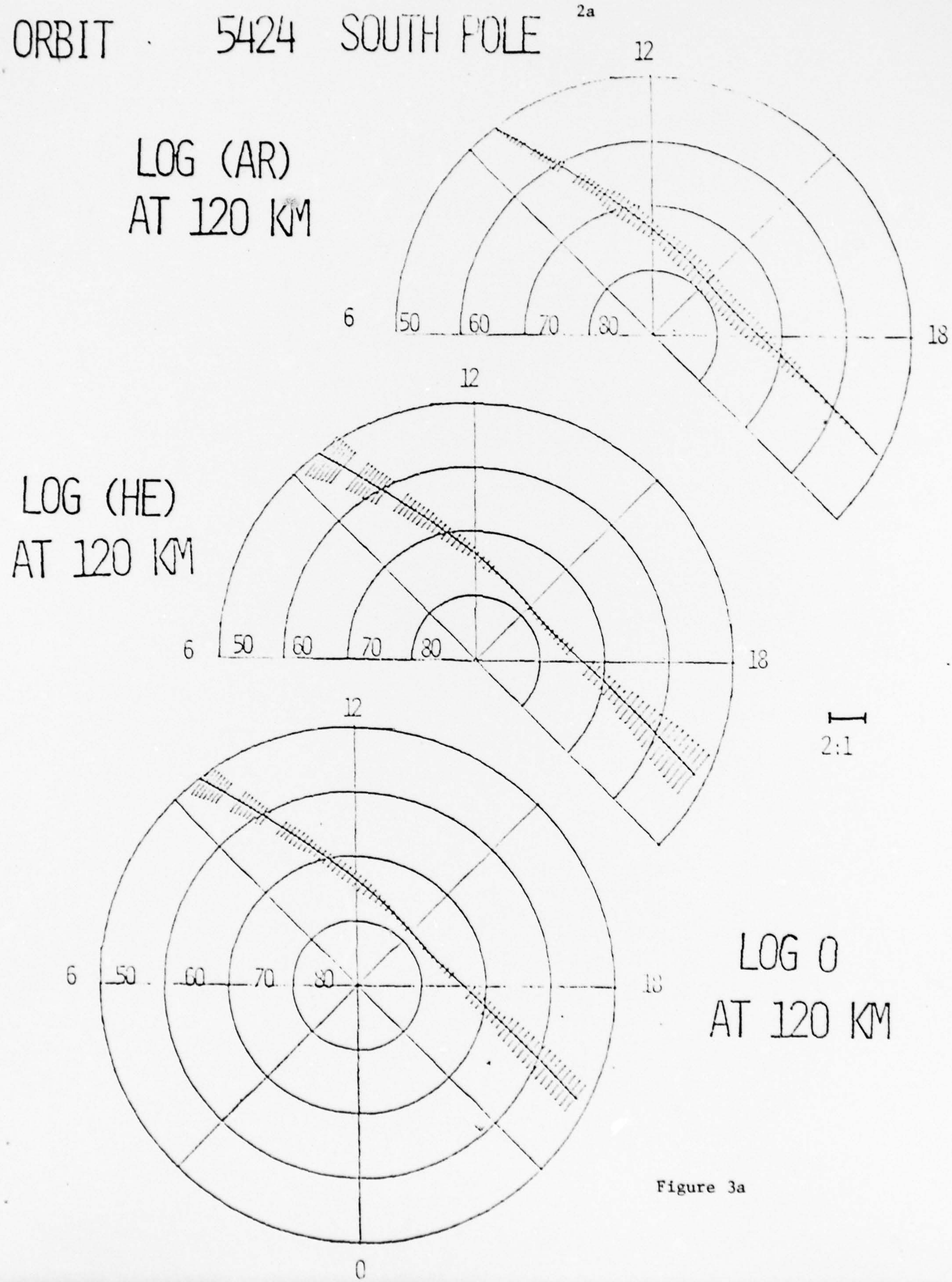
Figure 2

to be well correlated with the energy deposition and wind patterns as they are now understood the helium densities seemed to be very variable indeed and to vary in no consistent manner. Because of this it was decided not to publish these results until we had a chance to analyze the AE data. This has now been done and it was discovered that the AE helium data is very well behaved and follows closely the atomic oxygen variations, as would be expected for a constituent that is controlled greatly by winds. We have reexamined the OGO 6 data and determined that the reason for the problem arises from data at very high altitudes. When the data over 600 km are removed from the sample the remaining data are in good qualitative agreement with the seasonal and geographical variations seen on AE and on the atomic oxygen maps. We have not yet discovered whether the high altitude data is in error because of instrumentation problems or whether the densities in the exosphere are controlled by non local effects to such an extent that the altitude profiles depart markedly from a hydrostatic distribution.

The AE data in the cusp region are being analyzed to study the energy deposition in the cusp region, where energy deposition results in upward fluxes the densities of atomic oxygen and helium are depleted and heavier constituents like aregon are enhanced. These variations when compared to N_2 can be used to study the vertical structure of the divergence field and hence the energy transported out of the region by transport. Figure 3a shows the variation of argon helium and atomic oxygen in the region of the cusp and Figure 3b the ion velocity structure in the region for the same orbit.

References

Wilcox, J. M., "Solar Structure and Terrestrial Weather Science", 192, 745, 1976.



ORBIT 5424 SOUTH POLE
2a
LOG (AR)
AT 120 KM
12
6
50
60
70
80
18
LOG (HE)
AT 120 KM
12
6
50
60
70
80
18
2:1
12
6
50
60
70
80
LOG O
AT 120 KM
0

Figure 3a

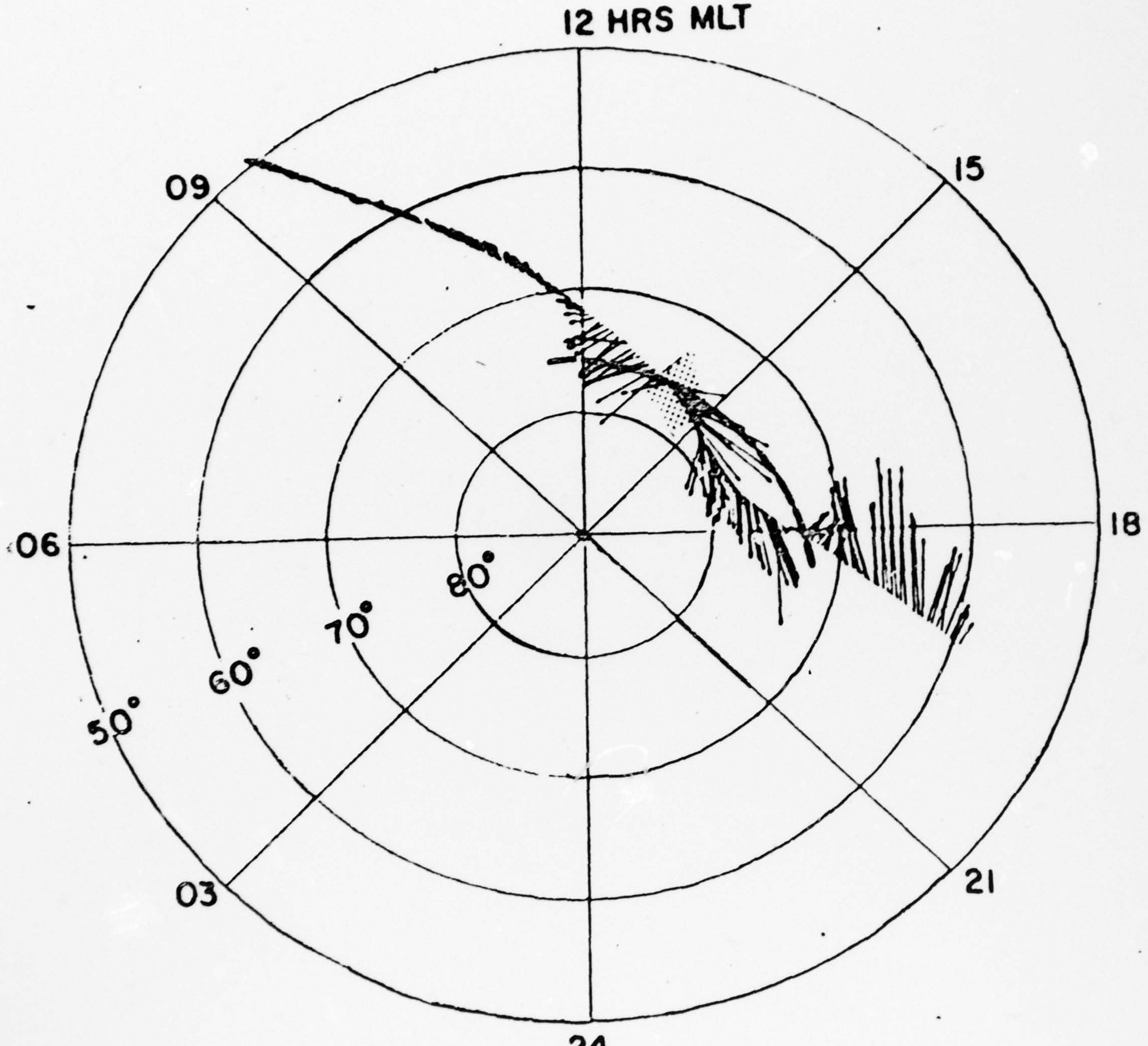


Figure 3b

Roberts, W. O. and R. Olson, "New Evidence for Effects of Variable Solar Corpuscular Emission on the Weather", Rev. Geophys. Space Phys. II, 731, 1973.

Hines, C. O. and I. Halevy, "Reality of the Nature of Sun Weather Correlation", Nature, 258, 313, 1975.

1.2 Planetary Magnetic Fields

1.2a General - J. S. Nisbet

A paper entitled, "Ion Exchange with the Solar Wind for Planets with Negligible Intrinsic Magnetic Fields" has been submitted to Planetary Space Science. After a few revisions it has now been accepted for publication. The paper presents a new theory for the induction of a magnetic field in the ionosphere of a planet due to interaction with the solar wind.

1.2b General - E. Bleuler

A revised version of the paper on the Energy Balance of the Nighttime Thermosphere was submitted on June 1 and has been accepted for publication by the Journal of Geophysical Research.

1.3 Neutral Densities in the Polar Thermosphere - C. Stehle

Neutral density variations in the polar caps have been related to equatorward fluxes above 120 km by Nisbet and Glenar (1977). These fluxes transport the lighter thermospheric constituents to lower latitudes and may affect the energy balance of the thermosphere considerably.

The density variations of atomic oxygen and helium under conditions of high and low solar activity are being studied. Data for the high and low portions of the solar cycle have been provided by mass spectrometer measurements from the OGO-6 and Atmosphere Explorer-C satellites, respectively. Averages of the O and He densities over the polar caps were taken for summer equinox, and winter using several ranges of magnetic activity.

The 0 densities at equinox for moderate magnetic activity appeared to be about 40% lower during solar minimum than at solar maximum. In fact, the densities were lower for all seasons over all ranges of magnetic activity during solar minimum, although the absolute magnitude of the decreases varied somewhat. The helium densities had larger variations with season and solar activity than did the 0 densities, but these variations followed the same general pattern as those of 0.

1.4 Thermospheric Neutral Densities in the Cusp Region - M. Griffis

Since beginning work at IRL, June 1, 1978, I have been looking at data taken by various instruments on board the Atmospheric Explorer (AE) satellites. My first month at IRL was spent becoming familiar with the AE data base through the Sigma 9 computer at Goddard Space Flight Center. Material was gathered for a short presentation by J. S. Nisbet at the AE team meeting on June 21 at Goddard.

July and August were spent in experimentation with different methods of looking at precipitating particle fluxes and neutral constituent densities and temperatures in the polar thermosphere, especially in the dayside cusp region.

The month of September was spent gathering information for a presentation by J. S. Nisbet on energy balance over the polar cap at the AE meeting in Bayse, Virginia on October 2, 1978. A high correlation was found between neutral density variations and ion flow reversals near and in the dayside cusp as seen by Heelis on certain orbits.

1.5 Electric Fields in the Bow Shock Region and the Troposphere - R. Caverly

Two new projects involving the use of the Arecibo Observatory are in the proposal stage. The first is the possibility of using the radar for magnetosheath boundary region investigations. The fluctuations in this region's

plasma, when excited by the radar energy, could scatter enough energy so that reasonable signal strengths can be obtained and used to deduce information about the region. An internal report (PSU-IRL-IR-65) relating some factors about the regions has been written as well as a proposal to be sent to the Arecibo Observatory.

A second project involves the effect of thunderstorms on the D and E-Regions. Specifically, electric fields much larger than normal, fair weather fields should be created over thunderstorms. A thunderstorm model is being worked out to give an estimate on the size of the fields and currents generated in the atmosphere as a result of the storm. A proposal to Arecibo will be written upon the completion and analysis of the model.

1.6 Infrared Heterodyne Spectrometry - D. Glenar

The period from April 1 - September 30, 1978 has been spent on the construction of a diode laser infrared heterodyne spectrometer at Goddard Space Flight Center, Greenbelt, Maryland. The instrument will operate in the wavelength range from 8 to 12 microns, the region of the atmospheric window, with resolving powers $\frac{\lambda}{\Delta\lambda}$ of the order of 10^7. This wavelength resolution is sufficient to resolve completely the shape of molecular rotation - vibration lines in either absorption or emission. Molecular spectra at these resolving powers yield a wealth of information about the environment in the region of the line formation.

In the past, a number of workers have employed heterodyne detection techniques at optical and infrared wavelengths. A survey of work performed prior to 1975, and a discussion of the theory and instrumentation used is given by Beynon et al. (1975). Much of the IR work has been performed near 10.6 microns (μm) where commericially available high power CO_2 gas lasers have been used as local oscillators. The disadvantage is that

observations are limited to within roughly 1 GHz, the width of the i.f. bandpass, on either side of the discrete CO_2 laser lines. The fraction of the spectrum observable is thus very small and limits one to observations of the same lines in remote sources or lines of other molecular species which happen to be in near coincidence.

Cryogenically cooled diode lasers have become commericially available in the last several years and offer the additional advantage of piecewise-continuous tunability over many wavenumbers. A prototype PbSe diode laser heterodyne spectrometer for operation near 8.5 μm was constructed at Goddard Space Flight Center (Mumma et al., 1975). It was found, however, that only one of several diodes placed in a liquid He dewar supplied power adequate where K is a constant, P_L and P_S are the local oscillator and signal powers on the detector and ϕ is the phase difference between the two signals at the i.f. Maximizing the i.f. signal requires the proper choice of system focal lengths and careful matching of the signal and L.O. spot sizes to the detector operature. The detector output signals are preamplified over the entire i.f. bandwidth, and further processed in an R. F. spectral line receiver to retrive the desired difference-frequency spectrum.

The system employs a synchronous detection processes where a motor driven chopper is used to look alternately on and off the source. Provision has been made for placing a precision blackbody reference into or out of either source or sky beams for system calibration purposes.

The assembly of the optical train shown in Figure 1 has been completed and visual alignment of the signal and local oscillator paths has been performed using a He Ne laser. Operation of the system in the heterodyne mode using the blackbody source for a signal will be attempted upon receipt of a satisfactory laser diode. The device has been ordered from Laser Analytics, Inc. and should arrive soon.

Diode Laser Local Oscillator

During the last several years considerable progress has been made in the development of diode lasers with single mode powers suitable for heterodyne work in the infrared. Recent studies by Jennings and Hillman (1978) for example, employ lead sulfer selenide (PbSSe) stripe geometry laser diodes operating below 70 K as tunable monochromatic sources near 10 μm (1000 cm^{-1}). The output frequency of these ternary composition devices can be preselected to within 1 cm^{-1} by varying the composition during fabrication. The output frequency can be further turned over several wavenumbers at cryogenic temperatures by varying both the diode temperature and the current flow through the diode. Typical diode current and temperature for heterodyne operation. The diode output frequency was found to be sensitive to mechanical vibrations and temperature fluctuations. As a result, astrophysical observations were limited to blackbody continuum measurements of the Moon and of Mars with signal to noise ratios of from 3 to 8. In the present system, still in the "bread board" stage, measures have been taken to eliminate or reduce all of these earlier problems with the hope of detecting and analysing line radiation from laboratory sources, the terrestrial atmosphere and ultimately, astrophysical sources.

Operation of the Sprectrometer

A diagram showing the layout of the system components is shown in Figure 1. Reflecting optics have been used throughout to minimize losses from internal reflection and absorption, an important consideration at these wavelengths. The source radiation is focussed onto an 800 μm "pinhole" at the location of the star tracker shown in the figure (the tracker is still in the developmental stage and no plans are being made to incorporate this device in the immediate future). The hole corresponds roughly to the diffraction limited spot size at 10 μm in the focal plane of the NASA 48" reflecting telescope, and represents the region over which

GSFC DIODE LASER HETERODYNE SPECTROMETER
OPTICAL FRONT END

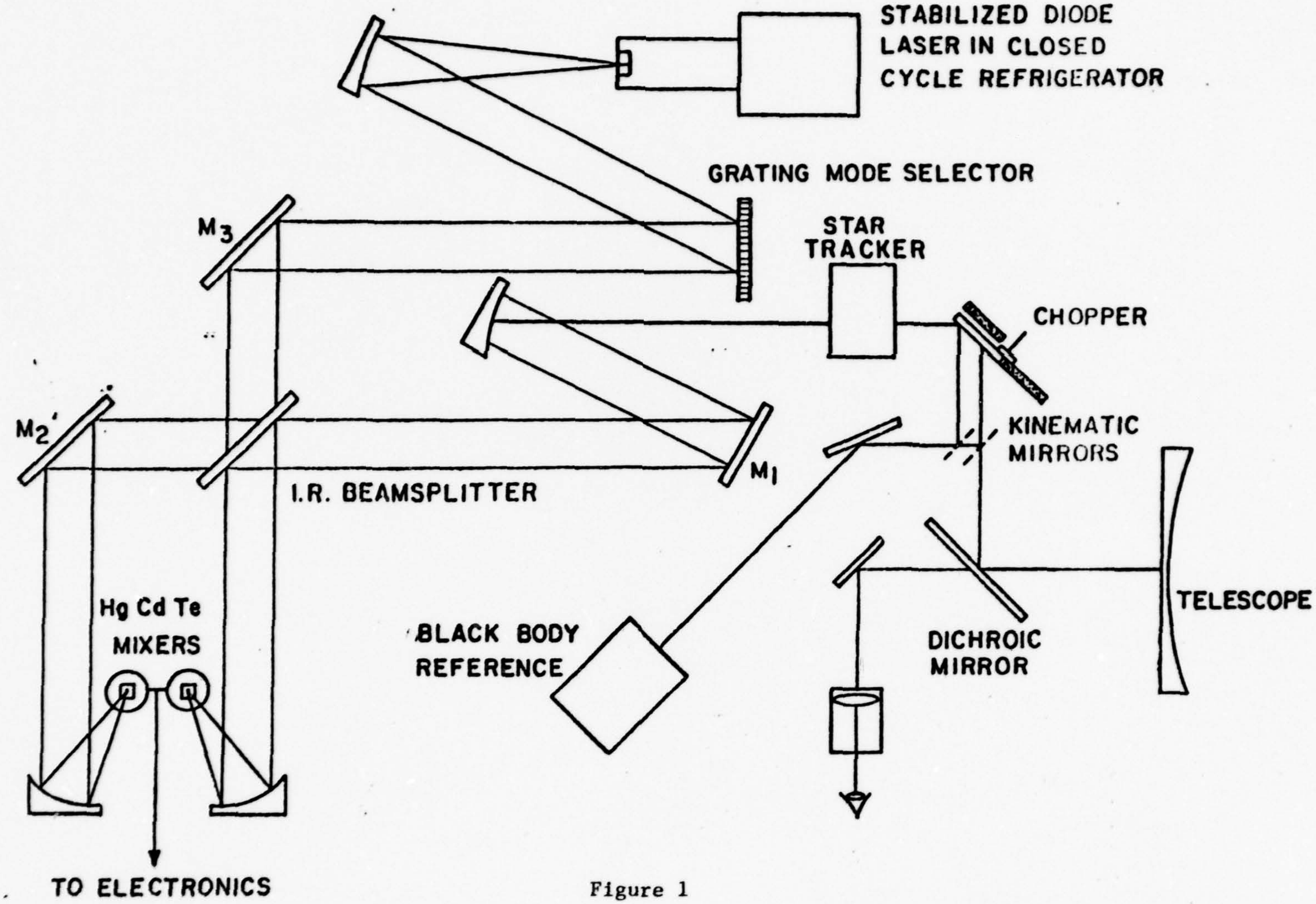


Figure 1

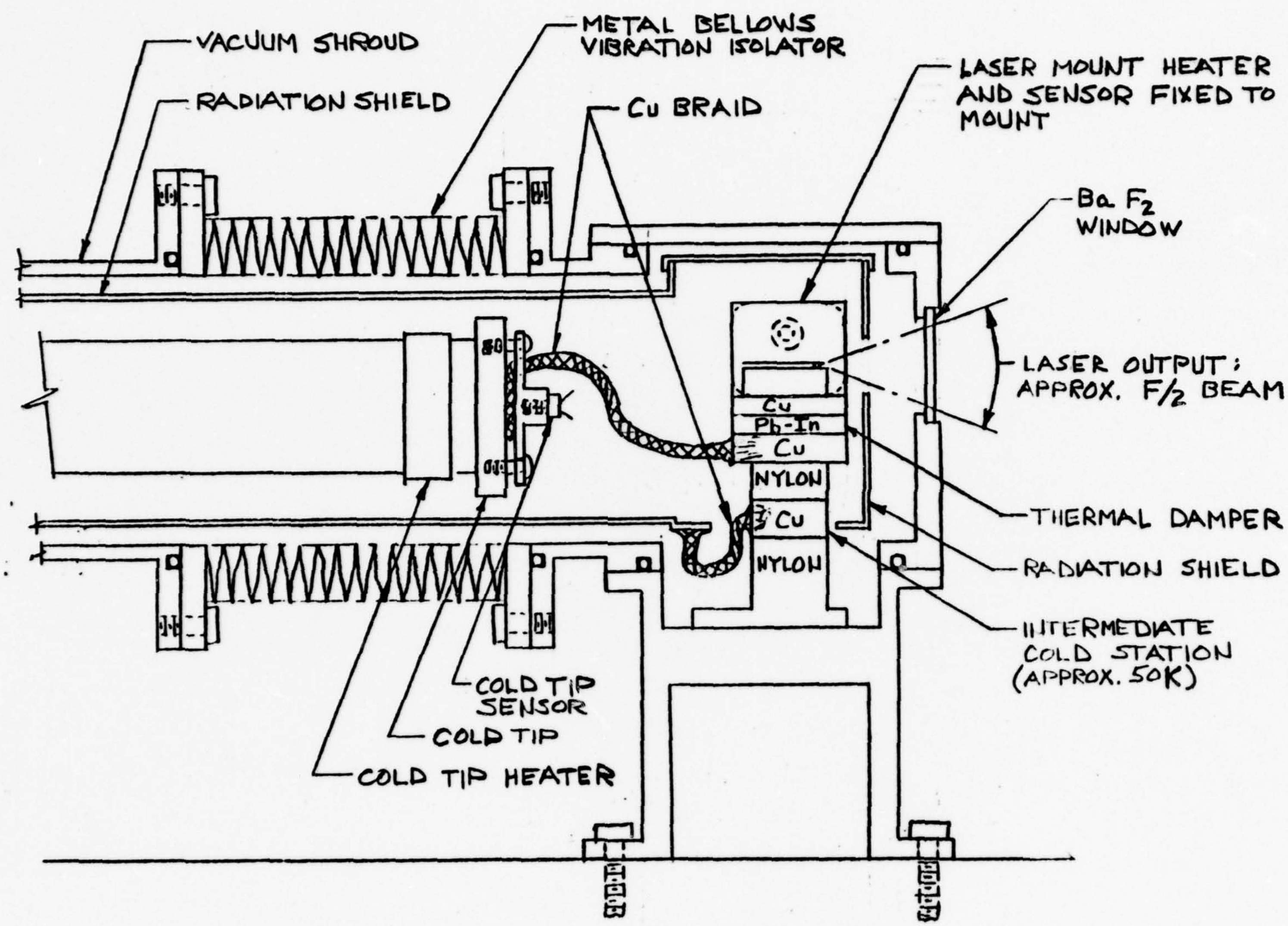


FIGURE 2 · DIODE LASER MOUNTING SCHEME

coherence of the signal radiation is preserved. The signal beam is aligned with the single mode output beam of the diode laser, assumed to be sufficiently monochromatic at frequency ω_o, and both are focussed onto a pair of mercury cadmium telluride (HgCdTe) photodiodes at 77 K, where the mixing process occurs. Since these detectors are sensitive to radiation near 10 μm and have response times (τ_R) of the order of 10^{-9} sec, they act as square law detectors for frequencies less than 1 GHz at the i.f., with output voltage or current given by

$$S_o\ (t) = K\left[P_L + P_S + 2(P_L P_S)^{1/2} \cos\ (\omega_{IF} t + \Phi)\right]$$

tuning rates for widely tuneable devices are 10 cm^{-1}/A and 4 cm^{-1}/K.

Figure 2 shows the manner in which the diode laser local oscillator has been mounted in a closed cycle helium refrigerator. The scheme employed for isolating vibrations and temperature fluctuations at the diode is based on the results of earlier work by Jennings and Hillman (1977 a,b). These authors were able to stabilize the diode laser output frequency against external vibrations to within $\pm$ 10 MHz. The system in Figure 2 uses a two-stage closed cycle helium cooling system manufactured by Air Products and Chemicals, Inc. Tip temperatures have routinely been held below 8 or 9 K at pressures less than 10^{-4} torr where the gas conductivity is very low. Under these conditions, the diode laser mount temperature has been found to vary between 12 and 13 K, a good starting point for the application of controlled temperature tuning. Current through the diode is varied using a high stability controllable current supply. The diode temperature is kept constant and isolated from cold tip fluctuations using a heater-sensor feedback loop at the cold tip and a high precision constant temperature controller (an auxilliary heater-sensor pair is located at the diode mount). Damping of any residual temperature fluctations occurs at the lead indium wafer near the diode. Exposure of the diode to room

temperature variations is minimized by the use of an intermediate temperature cold station connected to the radiation shield by a copper braid. Mechanical shock fluctuations in the laser output frequency are prevented by vibrationally isolating the laser mount from the cooler second stage. This is done externally by a short length of metal bellows at the shroud and the use of isolating pads between the 2nd stage cooler and the optical bench. Internal isolation is performed using flexible copper braid rather than rigid links for thermal conduction. Initial tests of the diode current and temperature control electronics have been performed using a defunct laser diode.
In addition, preliminary vibration tests show excellent vibration isolation between the 2nd stage cooler and the diode mount.

1.7 Ion Thermal Balance of Mars - R. P. Rohrbaugh

A paper analyzing the ion thermal balance of Mars was presented at the Spring, 1978 AGU Meeting. The main conclusions were that the physical mechanism which produced the high ion temperatures observed by Viking I is still unknown and that there is an inconsistency in modeling the ion densities given density and temperature data of Viking I. An attempt was made to reconcile the ion densities by changing various parameters such as the assumed magnetic field, the neutral densities, and the boundary fluxes.

It was found that the ion temperatures measured by Viking I were very much larger than can be explained using the heat inputs that are dominant in the earth's ionosphere and that some other major source is needed.

The basic reactions operating in the Martian ionosphere were studied and it was found that the dominant reactions, $O^+ + CO_2 \rightarrow O_2^+ + CO$ and $CO_2^+ + O \rightarrow O_2^+ + CO$, have an exothermicity of approximately 1.2eV and thus constituted a potential ion heating source through translational excitation of O_2^+. Calculations of the ambient ion heating and ion temperatures resulting from the thermalization of the energetic O_2^+ were performed. It was found that the energetic O_2^+ resulted in ambient ion heating rates over an order of magnitude higher than the heating by the ambient electrons in the region above 200 km and provided a much better agreement with the cooling rates as shown in Figure 1.

The heating source sufficed in raising the upper altitude temperatures greatly and provided a partial agreement with the observed ion temperature. This is shown in Figure 2 where the amount of translational energy going to O_2^+ has been parameterized and represented on an average energy $\bar{E}$ as shown. E_m is the maximum energy available to O_2^+ (about .6eV), Ψ_i is the

350 km boundary heat flux (equal to zero) and I is the magnetic field dip angle (equal to 2^o). In comparison to the temperatures obtained without the heating from the energetic O_2^+ the ion temperatures never exceed 30 K above the neutral temperatures at all altitudes above 200 km.

Results of this analysis are being written for submission to the Journal of Geophysical Research.

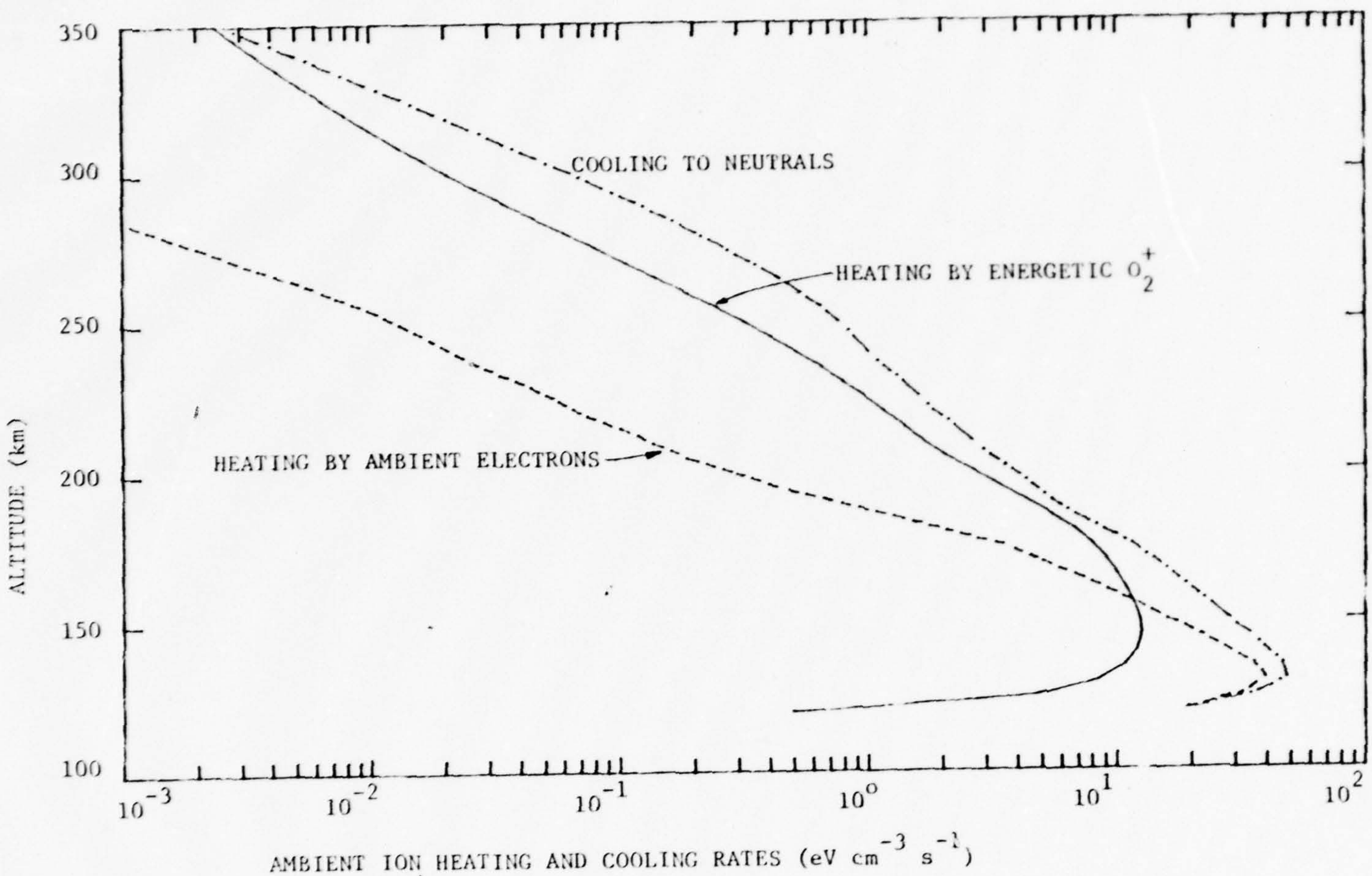


Figure 1: Calculated ambient ion heating and cooling rates.

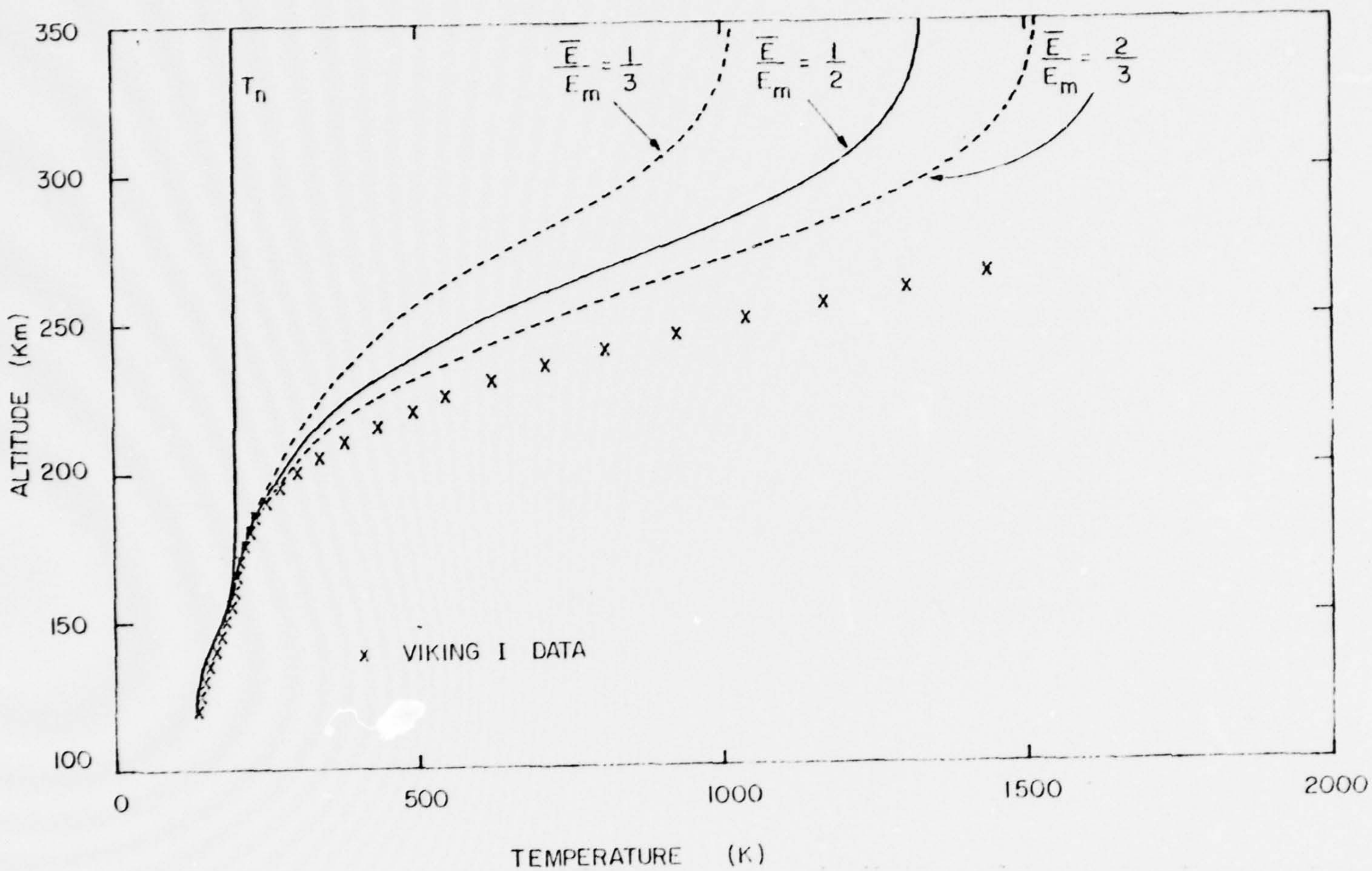


Figure 2: Calculated ion temperatures corresponding to the conditions $I=2^o$ and $\Psi_i = 0$ ev/cm^2/sec.

1.8 Mesospheric Processes - J. J. Olivero

The ground based water vapor microwave radiometer project has gained some momentum in recent months. We have received numerous components from NASA - Wallops Flight Center and the breadboarding of the basic radiometer is well along. The high speed digital autocorrelator, in the extended 16 channel version, is under construction at present. We have gained access to the surplus 8 foot parabolic dish antenna and solar tracking mount from the Radio Astronomy Observatory here at Penn State. A pedestal mount is being constructed with which it will be installed on top of the Walker Building; from which it will have a fairly unobstructed view of the southern skies. We are continuing a computer modelling study of the measurement sensitivity across the 22 Ghz line.

The modelling study of small ice spheres in the mesosphere was completed as an M. S. Thesis (Meterology) and will be published as a scientific report. A condensed version suitable for journal publication is in preparation.

In the study of the summer polar scattering layer, we have showed that the water content of the particle layer can vary over orders of magnitude depending on the size distribution of the particles assumed. Of equal importance is the realization that this calculated water content is rather independent of the local water vapor mixing ratio as long as saturation can be maintained. Thus we strongly question the position taken recently by Gadsden (1978) that the upper limit on particle size of 0.1 μ determined by Hummel and Olivero (1976) was totally at variance with estimates of the mesospheric water vapor content. The real analogy is that of tropospheric clouds which can contain many times as much liquid water (and/or ice) as vapor in the common volume. The requirement is a flux of vapor through the particle layer which is certainly consistent with the thermal and dynamical requirements for the existence of the layer itself.

References

Gadsden, M., "The Sizes of Particles in Noctilucent Clouds: Implications for Mesospheric Water Vapor", J. Geophys. Res., 83, p. 1155, 1978.

Hummel, J. R. and J. J. Olivero, "Satellite Observations of the Mesospheric Scattering Layer and Implied Climatic Consequences", J. Geophys. Res., 81, p. 3177, 1976.

1.9 Microparticles in the Mesosphere - R. Bevilacqua

Many characteristics of the electrical structure of the D-region can be explained by postulating the existence of volatile particles throughout the mesosphere, at all times of year. I have been examing the simplest model of such particles, small ice spheres. A study of the existence and lifetimes of small ice spheres in the mesosphere has been essentially completed. The results show that ice spheres can only persist in a very limited region of altitude, latitude, and season centered about the summer polar mesopause. This is the classical result. Maximum particle lifetimes outside of this rather limited existence region are on the order of minutes or seconds. Thus we conclude that mesospheric particle phenomena, outside of the noctilucent cloud region, are most likely not attributable to small ice spheres. A thesis entitled "Ice Particles in the Mesosphere", in which this study is discussed extensively, has been completed during this six-month period.

Preliminary results of the study are discussed in a short paper entitled "Physical Properties Affecting the Existence of Small Ice Particles in the Mesosphere", by Dr. John J. Olivero and myself. This paper has been presented by Dr. Olivero, in early June, at the 1978 COSPAR conference.

1.10 Light Scattering by the Mesospheric Particulate Layer - D. Young

Work has essentially been completed on our study of the characteristics of particles in the polar mesospheric scattering layer

based on OGO-6 photometric measurements. I am presently writing a scientific report summarizing this study.

It has been demonstrated that if the layer is assumed to be a monodispersion of particles with a radius of 0.13μ, then this implies a number density of 15-40 cm^{-3} and an equivalent mixing ratio within the layer of 20-75 ppmv. However, the layer is most likely polydisperse. Incorporating a distribution of sizes into our model increases our estimates of the mixing ratio by 1-2 orders of magnitude.

In addition, we looked at the effects of including particles of large radius ($R > 0.15\mu$) as suggested by Gadsden (Anal. de Geophysics, 1977). However, this decreases our estimates of the mixing ratio by less than a factor of 2.

Currently, we are investigating the feasibility and usefulness of repeating the experiment using synchronous measurements of the oxygen green line (0.5577μ) and the Lyman-alpha line (0.1216μ).

2. E and F Region

2.1 F-Region Dynamics - L. Carpenter

A paper "Continuous Scan Measurements at Arecibo to Examine Conditions for Spread F" is being prepared for presentation on December 4 at the Fall, AGU Meeting in San Francisco. This paper discusses the measurements from February 24-25 and March 3-4, 1977 from about 1700 to 0400 LT. The peak height and peak density are examined to determine lateral variation present when Spread F occurs. For each 90^{o} section of the continuous scan made, about 70 profiles are taken in three-second intervals and contiguous groups of ten profiles are averaged together to yield seven profiles for each section. Correlation of ionospheric motion with ionogram measurement is also examined to test the various theories of Spread F.

Four measurement periods (1600 - 2400 AST) are scheduled in cooperation with Dr. John Meriwether at the Arecibo Observatory between December 28, 1978 and January 3, 1979. The Febry-Perot interferometer will be used to determine east-west neutral winds at F Region heights.

Richard Bachman's report number 459 on "Continuous Scan Velocity Determinations for Spread F Measurements" has been completed and will be available shortly. This report discusses the method of velocity determination and develops an algorithm for determining velocities from line-of-sight data. Velocities for the February 24, 1977 data are analysed and the anti-correlation between the perpendicular and parallel components are verified as previously reported. An error analysis is carried out on this technique to examine its feasibility.

The paper "Evidence for a Magnetospheric Effect on Mid-latitude Electric Fields" with C. A. Gonzales, M. C. Kelly and R. H. Holzworth was published in the Journal of Geophysical Research, 83, 4397 - 4399, 1978.

2.2 D-Region Electric Fields Due to Thunderstorms - J. S. Nisbet

Work has been done and the estimation of the electric fields induced in the ionosphere by thunderstorms. It is known that the currents above a large storm are of the order of 1 amp in the upward direction and that these currents from tropical thunderstorms form the driving generators for the fair weather field. We have investigated the effects of these currents in the ionospheric D-region using measurements by Hale (1978) of the conductivity under various conditions. It appears that very large vertical electric fields of the order of 1 volt per meter may be generated above tropical thunderstorms. These fields will drive positive ions up in the ionosphere and negative ions and electrons downward. The effect may well be to raise meteoritic ions from the region of their formation up into the E-region where sporadic F is seen. A model is being developed to study this effect and if the calculations continue to look promising it is intended to make a series of measurements at Arecibo, where such storms are a regular event, of the effects on the D-region densities.

2.2a Variations in Ionospheric Current Owing to the High Latitude Birkeland Current and Cusp Current - C. H. Li

(1) After the improvement of the input current data, the correct feature for the case of $K_p \simeq 0$ have been obtained. The results with global characteristics of the potential electrical field and its current in the ionosphere are presumably coincidental with the present knowledgements.

(2) The remaining problem is that we couldn't get good results for the disturbed case, for example, $K_p \simeq 3$, since we only have the conductivities data for $K_p \simeq 0$ instead of $K_p \simeq 3$. What we urgently need is to look for or build up the conductivity model corresponding the case of $K_p \simeq 3$ or so.

2.3 General - E. Klevans

I have been working on several problems. First, I worked with John McCowan on the interpretation of results from the continuous density scan mode at Arecibo. We have observed significant density gradients, wave like behavior, and gradients in hm (ionospheric tilts) for the nighttime F-region. These results will be presented at the AGU meeting by Lynn Carpenter.

I have also worked with Richard Bachman on the analysis of the continuous scan velocity determination. Bachman has written a report on this topic.

2.3a General - J. McCowan

During the period from April to September of 1977 I have continued to work with data obtained from the Arecibo Observatory in the I-50 moving beam experiments. Electron density and velocity data were compiled during these experiments in a continuous (in time and space) manner. Working with electron density versus altitude, I have attempted to manipulate the data to give an accurate description of the behavior of the peak density and height at peak density. It is hoped that from this description a method of separating the temporal and spacial behavior of the peak can be found.

2.4 Mid-latitude Spread F - C. Cranmer

Ion drift velocity components were analyzed for four nights during which Spread F occurred. It was found that between 2100 and 2200 hours, several component velocities changed direction. The north-south velocity, which was northward prior to this time, was southwards after 2200 hours. An accompaning direction change was seen in the velocity along the magnetic field. Polewards and downwards prior to 2100 hours, it was equatorward and upwards after this time. The velocity transverse to the field

changed direction from upwards and polewards and equatorwards around 2100 hours. The vertical velocity remained downwards and the east-west velocity component remained downwards and the east-west velocity component remained eastwards from 1800 to 0200 hours. These velocities were introduced into a model of tubular field-aligned irregularities, which was constructed based on density profiles from Arecibo. The model density profiles are being compared to the Arecibo profiles.

A paper is being written on the results of the electron density and velocity analysis and of the model comparison with Arecibo measurements.

3. D-Region

3.1 General - L. C. Hale

A paper on "Middle Atmosphere Vertical Electric Fields", was presented by Hale, L. C., J. J. Olivero (Pennsylvania State University) and J. D. Mitchell (University of Texas at El Paso) at the COSPAR symposium in Innsbruck on May 29. The abstract follows:

Evidence is accumulating for the existence of large (several volts/meter) vertical electric fields in the middle atmosphere. Workers in the USSR have identified a "permanent" field in the middle mesosphere which may be due to a global current system flowing through a region of low electrical conductivity. Cells of vertical field in the stratopause region occur at the same altitude where aerosol layers are sporadically observed, suggesting a possible relationship. A large downward field in the high latitude nighttime mesosphere apparently vanished during an auroral event. We hypothesize that this was due to the "short-out" of the electric dipole implied by the pre-auroral measurements and that this may explain lower atmosphere electric field effects that have been observed during aurorae.

A field operation in Laramie in July tested a developmental model of the planned February 26, 1979 solar eclipse payload, which will combine probe measurements, response of the atmosphere to a variety of radiation wavelengths, and electric field measurement.

An invited paper on "Micrometeorite Transport Through the Atmosphere", was presented in August at the 4th Gregynog Astrophysics Workshop, held at Gregynog, a country estate near Newtown, in Wales. This conference brought together international experts in the fields of astrophysics and the origins and evolution of life, to consider the development of life in the universe. Much of the discussion centered about the radical new ideas of Sir Fred Hoyle and Professor Chandra Wickramasinghe of Cardiff

that much of evolution takes place in interstellar space, particularly on comets. They base their case on the organic nature of interstellar dust, as observed in infrared astronomy. Perceiving some flaws in Darwinian concepts, Hoyle and Wickramasinghe have asserted that evolution involves the continual biological interaction of extraterrestrial material of viral nature with the creatures of earth. In this scheme an important role is assigned to disease, which they believe to be mainly of extraterrestrial origin, relying for evidence on the history of diseases since antiquity, including thucydides and unusual features of the appearance of disease such as the simultaneous appearance of the 1918 influenza pandemic in Boston and Bombay. They have recently completed a study of flu outbreaks in British schools last winter, and claim to have proved that the disease is definitely of extraterrestrial origin, Hoyle believing that influenza in particular develops on Halley's Comet. Professor Hale's paper presented evidence, obtained in sounding rocket programs of the Ionosphere Research Laboratory, that the influx to the earth of particles the size of viruses is millions of times greater than previously thought, and may be controlled by electric fields in the atmosphere associated with thunderstorms and sunspots.

3.2 General - A. J. Ferraro

Prepared extensive renewal proposal to NSF during months of April and May.

Evaluated new digital recording facilities for cross-modulation experiment and ordered necessary supplies and equipment.

Prepared paper for presentation at Commission G, URSI, at Boulder, Colorado during November 1978.

3.3 General - H. S. Lee

New wave interaction data synthesis technique was developed, incorporating more accurate expressions of index of refraction, for processing data procured at widely varying magneto-ionic conditions. This technique was proven useful in processing Arecibo data.

A major scientific research proposal was prepared and submitted to NSF and it has been approved for funding.

3.4 Arecibo Wave Interaction Measurements - M. Sulzer

Final analysis of the wave interaction data used in the gravity wave problem indicates that most of the energy in the fluctuations is associated with a process in which there is only a small amount of vertically propagating energy. This is in agreement with the propagation of AGW's in the mesosphere, since most of the energy will be reflected from the temperature gradient. Some vertical energy propagation has been detected in various frequency ranges; the results are rather complicated and are discussed in the thesis. The final draft will be completed in January.

3.5 D-Region Ionospheric Modification - A. Tomko

An analytic model of the time variation of the electron density distribution in the D-region during continuous high power heating by electromagnetic waves has been developed. The analytic solution for the transient electron density during heating agrees very well with that predicted by a previously developed numerical model which employed the Runge-Kutta method to solve the ion continuity equations of the Mitra-Rowe chemistry scheme. The analytic model gives one a better physical insight into the mechanisms controlling the transient behavior of the electron density and allows one to calculate absorption and wave interaction effects which heretofore required prohibitively long computation time using strictly numerical methods.

3.6 Arecibo H. F. Facility - J. Breakall

During this period I have worked with Dr. Sengupta on obtaining his X-ray spectrum model to be incorporated in the Rowe-Mitra D-region chemistry program.

I have also been working closely with Drs. Suman Ganguly of Arecibo and John Mathews of Case Western on using our incoherent scatter data to obtain a new NO profile in the D-region and to obtain time dependent parameters of the diurnal chemistry from experimental density information and the Rowe-Mitra program.

4. Mass Spectrometer Measurements

4.1 Ion Analysis with Mass Spectrometers - General - B. Kendall

Various types of nonmagnetic mass spectrometers are being studied with a view to establishing their value for measuring the ionic composition of the D region of the ionosphere. Applications to measurements in the upper stratosphere are also being studied.

During this reporting period an evaluation of the mass discrimination of ion detectors used in D-region mass spectrometers has been continued. Development of the simple Eiber-Loeb mass filter has also been continued. These instruments should theoretically be capable of operation down to about 50 km without the use of vacuum pumps. Further information on these two topics is given in sections 4.2 and 4.4, respectively.

Design studies have also been begun on a new project which may be carried out in conjunction with the NASA Lewis Research Center. This work would involve the use of a relatively high performance nonmagnetic mass spectrometer for a study of the ions and neutrals given off during the breakdown of insulating surfaces in spacecraft. It appears that quite straightforward adaptations of existing apparatus may be adequate for this work.

4.2 Ion Analysis in the D Region - B. Kendall

The previous report in this series gave a detailed discussion of several processes which introduced mass discrimination in existing types of D-region mass spectrometers. Work on this project has continued. Additional evidence of discrimination against high masses has been obtained and incorporated in an expanded version of the paper originally submitted for publication.

This work on mass discrimination indicates that an extreme sensitivity loss may occur in existing types of mass spectrometers at masses higher than

about 175 amu. This is important even though many D-region mass spectrometers are set to scan only up to some lower figure, because a high-pass mass filter mode is used on the quadrupole mass analyzers employed in most experiments. Its purpose is to check for the presence of ion currents at masses above the top of the scan range. Absence of substantial detector output currents in this mode has in the past been taken as proof of the absence of the corresponding heavy ions. It is now clear that this conclusion has not been justified. Re-examination of existing data obtained in the high-pass mode is desirable.

4.3 Brownian Motion/Diamagnetic Levitation - R. Friesenhahn

An experimental study of factors affecting the motion of small particles in a low density gaseous environment has been made. A paper on this topic appeared in VACUUM, 27, 589 (1977).

The movements of submicroscopic particles may have relevance to the transport of aerosols in the upper atmosphere, and provide absolute measurements of gas density and temperature in ultra-high vacuum environments.

Since S. M. Rossnagel's departure to work at the Princeton Plasma Physics Laboratory, the original levitation equipment has been extensively modified. A new magnet configuration with more stable levitation and increased accessibility has been designed and tested. The levitation cell and related equipment are under construction, as are modifications to the ultra-high vacuum system to increase the pressure range. Tests with the previous vacuum system gave work chamber pressures of about 1.5×10^{-8} Torr. Hopes are for extending this to about the 10^{-10} Torr range. Present expectations are for experimentation to begin in late October.

4.4 Mass Filters - F. Schwab

Work on the mass filter project has been taken over by F. Schwab following the departure of postdoctorate fellow B. Lightfoot in late summer.

Primary interest is still directed toward the Eiber-Loeb mass filter, the prototype of which has undergone extensive preliminary testing. The advantages of this filter include its simplicity and light weight, and its ability to operate at altitudes down to about 50 km.

The RF feed system to the filter has been changed to a symmetric above-and-below-ground output potential. It is believed that this modification will minimize possible interactions of the ion beam with the stray electric field created between the filter grid and its metal enclosure.

Future experiments are intended to find the filter's maximum operating background pressure, to test if the transmission coefficient is independent of the velocity of the ions, and to determine whether scanning the frequency or amplitude of the electric field between the grid wires is more efficient in obtaining the transmission curve. In addition, attempts will be made to employ signal processing, such as differentiation, to analyze the output from the filter.

5. Direct Measurements

5.1 Methods of Minor Constituent Measurements - C. Croskey

Our Gerdien Condenser, dropsonde data from the Stratcom VIII-A balloon flight was presented at a data workshop at Goddard Space Flight Center in April.

Later in the spring, at a Project Initiation Conference at Wallops Island, Virginia, a multiple lamp Astrobee-D payload for use in the February 1979 eclipse was defined. Through the summer a balloonsonde test bed was built. This package contained three types of ultraviolet lamps (Kr, Xe, and H_2 RF discharge) and 300 watts of incandescent lamps. After each lamp is turned on individually, a lamp off background cycle is taken. The positive and negative conductivity enhancements produced by the lamps are observed by the standard blunt probe configuration. This balloon package was flown by Dr. Hale as part of the Atmospheric Electricity Workshop in Laramie, Wyoming. Work has begun on the similar Astrobee-D, Eclipse 1979 payloads.

With the help of Harry Atwater, the E-Field data from the "Aurorozone 78" campaign in Poker Flat, Alaska, has been reduced.

Several hardware items procured by NASA, Wallops Flight Center have been added to the 22 GHz radiometer and with the help of several student technicians the high speed autocorrelator is being expanded to 16 points.

6. Atmospheric Reactions

6.1 The Reactions of CCl_3O_2 with NO and NO_2 - R. Simonaitis

The reactions of CCl_3O_2 with NO and NO_2 have been studied by steadystate photolysis of Cl_2-$HCCl_3$-O_2-N_2-NO-NO_2 mixtures at pressures of $\sim$1 atm and temperatures of 227 and 296°K. The reactions are

$$CCl_3O_2 + NO \rightarrow CCl_3O + NO \qquad 3$$

$$CCl_3O_2 + NO_2\ (+M) \rightleftarrows CCl_3O_2NO_2\ (+M) \qquad 4,-4$$

with $k_4/k_3 = 0.60$ independent of temperature.

The thermal decomposition of $CCl_3O_2NO_2$ produced in the reaction of CCl_3O_2 with NO_2 was studied over the temperature range of 268-298°K at 1 atm total pressure.

$$CCl_3O_2NO_2\ (+M) \rightarrow CCl_3O_2 + NO_2\ (+M) \qquad -4$$

The following Arrhenius expression was obtained: $k_{-4} = (35.9 \pm 23) - (22000 \pm 1300)/RT\ s^{-1}$. In the stratosphere at 220°K the thermal lifetime of $CCl_3O_2NO_2$ will be 15 days. It is suggested that $CCl_3O_2NO_2$ may be a stratospheric constituent.

Also worked with Dr. E. Sanhueza, Dr. S. Glavas and Ms. W. Wongdontri Stuper on the following projects:

Dr. E. Sanhueza studied the reaction of CCl_3O_2 radical with SO_2 by flash photolysis technique.

$$CCl_3O_2 + SO_2 \rightarrow \text{Products} \qquad 1$$

The rate constant for reaction 1, $k_1 \simeq 6 \times 10^{-15}\ cm^3\ s^{-1}$.

Dr. S. Glavas is working on a project to study the reactions of the CCl_2FO_2 radical with NO and NO_2. Preliminary results show that

CCl_2FO_2 reacts with NO_2 as follows

$$CCl_2FO_2 + NO_2 \rightarrow CCl_2FO_2NO_2 \qquad 2,-2$$

The compound $CCl_2FO_2NO_2$ is unstable and decomposes via the reverse of reaction 2.

6.2 The Reaction of ClOO with NO - W. Wongdontri-Stuper

Reactions of ClOO with NO were studied by the photolysis of Cl_2 in the presence of NO and O_2 with or without added N_2 using steady state photolysis. ClOO is formed by the reversible reaction

$$Cl + O_2 + M \rightleftarrows ClOO + M \qquad 1,-1$$

The results indicate that ClOO reacts with NO via two channels:

$$ClOO + NO + \rightarrow NO_2 + ClO \qquad 2a$$

$$\rightarrow ClNO + O_2 \qquad 2b$$

The atmospherically important values $k_{2a,}K_{1,-1} = (1.5 \pm 0.6) \times 10^{-32}$ cm^6 s^{-1} and $k_{2b}K_{1,-1} = (1.6 \pm 1.0) \times 10^{-31}$ cm^6 s^{-1} were evaluated at 298^{o}K based on the value of $(1.1 \pm 0.3) \times 10^{-31}$ cm^6 s^{-1} for the reaction

$$Cl + NO + N_2 \rightarrow ClNO + N_2$$

The ratio k_{2b}/k_{2a} was found to be 11.0 + 2.2. The values of $k_{2a,}K_{1,-1}$ and $k_{2b}K_{1,-1}$ obtained in the present work when combined with a reasonable value of $K_{1,-1}$ at stratospheric temperatures indicates that reactions 2a and 2b are probably not important in the stratosphere.

7. Particle Collection and Ionosphere Composition Studies Using Rocket Borne Probes

7.1 General - T. M. York

The work on this project continued along lines established earlier and presented in the previous progress report. However, the results of detailed studies altered the direction of some of the efforts, and these will be reviewed below.

One substantial infusion of information to and interest in this program occurred during this reporting period as a result of a three week visit by Dr. York to White Sands Missile Range during the month of August. Cooperative efforts were begun in an attempt to match electron density data (partial reflection) with electron densities predicted from rocket borne blunt probes using new analysis techniques. This work is being carried out with R. Olsen at White Sands Missile Range and J. Mitchell at University of Texas in El Paso. Plans were laid for organizing a sequence of rocket shots during the Winter 1979 Eclipse Campaign to allow comparison of different electron density diagnostics.

The work on analyzing Gerdien condenser flows is proceeding well. The interesting effects of fields, chemistry, and a UV ionizing lamp can now begin.

The effort to develop an exact theory for analyzing electron collection was reduced in scope. It is now intended to develop an approximate theory and to identify further detailed studies that may be considered if circumstances are appropriate. The work being undertaken to test blunt probe electron collection theories in controlled laboratory experiments has progressed, and it is felt that experimental data are now much more reliable. Improved theories for analyzing Langmuir probe data have been incorporated; impact pressure measurements and particle collection with

a new, correctly scaled blunt probe are to be done shortly.

The work with RF generation and heating of ionosphere type plasmas has primarily been evaluative. Plasma can be generated, but Langmuir probing has been found to be difficult and electron temperatures are apparently quite high. A decision on whether to continue this work will be made in the near future.

7.2 Numerical Study of Particle Collection in a Gerdien Probe - S. Chang

The analysis of the viscous and invicid flow in an annular Gerdien probe is nearly complete.

The axisymmetric boundary layer flow near the forward stagnation point, the viscous flow along the after body, as well as the viscous flow along the outer cylinder have been formulated, programmed, and matched to the potential flow. For different flight altitudes, particle paths can now be determined for zero electric field and no chemical reaction.

It is intended to extend the numerical study to charge particle behavior in the flow field with electric field and chemical reaction. The paths of individual particles and the mode of general particle collection of ions flowing into a Gerdien can then be identified. The chemistry effects on ions generated by a blinking UV lamp will also be included with the electric field effects in order to clearly identify the behavior of this type of device.

7.3 Electron Collection by Blunt Probes - C. Wu

During this period, there has been a mapping of a range of parameters indicative of the electron collection process to help identify reasonable approximations for theory. Detailed calculations have been done for both ARCAS sized blunt probes and the smaller LOKI DART sized blunt

Electron collection data has been analyzed for a number of specific days that were studied earlier by Lai; a comparison of electron density predictions with different methods of analysis were made. This work will continue.

Recent data taken with LOKI DART probes at the same time that partial reflection data was available have been analyzed. Data taken on October 2, 1975 at White Sands Missile Range with partial reflection indications of electron density at 70 - 90 km is being compared with electron density indications from blunt probe data at 40 - 70 km.

7.3a <u>Laboratory Studies of Blunt Probe Particle Collection</u> - R. Brasfield

A glow discharge chamber probe positioning mechanism, and single and double-Langmuir probes have been built and tested.

The double-Langmuir probe was found to be unsatisfactory as the reference diagnostic, because of an electrical problem which could not be fully resolved. Specifically, voltage gradients in the discharge caused substantial biases between probe electrodes and made data taking difficult. The single probe technique was then investigated, and it has proven successful in the evaluation of the test plasma density and temperature. Results have been consistent and reproducible.

Single probe Langmuir data has been taken, and it has been reduced for both static and flowing (subsonic) plasma conditions. The altitudes of 90, 80, and 70 km have been studied extensively. Preliminary tests have been done for the 60 km regime.

Because of the large Debye lengths evident in some of the test conditions, a recently published theoretical development has been used in the reduction of the single probe data. The normal reduction of data for T_e determination employs the technique of plotting the ln (je) VS V, as discussed by

Sonin. When large Debye lengths are present, however, Chang and Lafromboise have noted that T_e is over-estimated using this procedure. They evolved the correct technique of plotting the ln (je/V) VS V; (requiring that the current density, je, be divided by the probe voltage).

The blunt probe to be used in the test facility has been geometrically scaled down 2 orders of magnitude from the full-size ARCAS model probe. The scaling achieved is a considerable improvement over earlier test probes, but is not precise because of the difficulty in machining to the tolerances involved. The cross sectional and surface areas of the stainless steel tubes involved are within 10% of the required dimensions.

Impact pressure probe studies of the subsonic flow field will be carried out using a capacitance monometer. This unit is now undergoing checkout and calibration.

References

Sonin, A. A., AIAA Journal, 4, No. 9, September 1966.

Chang, Jen-Shih and J. G. Laframboise, The Physics of Fluids, 19, January 1976.

7.4 RF Generation of Plasma for Ionosphere Flow Studies - H. Tarng

It has been demonstrated that an RF generator operating at 21.4 MHz 200 watts CW driving on oscillating circuit can generate and sustain a plasma over the range from .2 to 20 T.

In this reporting period, a double Langmuir probe has been fabricated for the purpose of evaluating RF plasma properties. Simply inserting the probe near the plasma results in extraneous signals at RF frequencies; these were detected on an oscilloscope. A system with long pyrex tube which would allow plasma flow away from the RF coil, and thus reduction of RF pickup at a cool plasma position, was constructed.

Tests with the Langmuir probe in a DC glow discharge in this have generally been inconclusive.

B. SUPPORTING OPERATIONS

102 Programming

102.1 - R. Divany

Reduction of a large amount of wave interaction data was carried out following a lot of changes to the programs to get them into good working order. Graphic capabilities and curve fitting was added to produce plots of the analyzed data.

The IGRF 75 (A New Earth's Magnetic Field Model) program was modified and compared with other available models.

A series of current model runs were done following changes to the conductivity program. The changes required enhancement of the polar ionosphere calculations. Comparisons with other data were done.

The MSIS neutral model was adopted to our system and coupled with programs which were developed to process Atmospheric Explorer series satellite data. A series of programs were written to display and compare A.E. and OGO-6 data.

A number of improvements were made to our graphics software during this period when time permitted.

Some maintenance to software in our library was necessary, particularly to the AMP and ASAP packages.

102.2 - B. Beiswenger

Work continued for the global model of the ionospheric currents and electric fields. All the available processing was done to compare Dr. Nisbet's and Chi-Hsi Li's conductivities for Equinox, using two current models. Then the processing was applied to three new current models. After a revision of the model, these three current sets were again run and corresponding plots made. An additional trio of current

models, with and without cusp currents, were run with both Nisbet's and Li's conductivities and a selection of plots was completed.

We received 23 tapes from Goddard with Atmosphere Explorer experiments OSS and NATE data, which were rewritten for IBM 370 compatibility. With Bob's programs the data was condensed, coupled with the MSIS neutral thermosphere model, and written on new tapes. A data synopsis and selection program was run, and sample plots were made with the three-dimensional spherical plotting package Bob prepared for C. Stehle. Later in this period various plots were made for presentations at the A.E. research users' conference.

Electron density plots for selected values of collision frequency with polynomial fits to the data were done for Dr. Lee.

Some typing and plotting of data was done for R. Rohrbaugh.

A large quantity of data processing for Dr. Sengupta included correlation studies, least squares, spline, and polynomial fitting of his data.

A sample water vapor profile was constructed for ground level through 80 km. for Dr. Olivero. This model was used with the atmospheric radiative transfer program to examine absorption and emission for various zenith angles.

103 Library

103.1 - D. Thompson

One Scientific Report had been received and distributed (458).

Five reprints written by staff members have been received into the library.

C. OTHER ACTIVITIES

201 Publications and Presentations

201.1 Scientific Reports

457 Petruno, Patrick T., "A High Speed Digital Autocorrelator and Its Application to Mesospheric Water Vapor Detection."

201.2 Papers Published

77-2 Hale, L. C., C. L. Croskey and J. D. Mitchell, "Middle Atmosphere Ion Measurements During January 1976", COSPAR, Pergamon Press, pp. 143-146, 1978.

505 Schaal, Diane, Kenneth Partymiller and Julian Heicklen, "The Inhibition of Photochemical Smog VII. Inhibition by Diethylhydroxylamie at Atmospheric Concentrations", The Science of the Total Environment, 9, pp. 209-226.

77-4 Hale, L. C., "Particulate Transport Through the Mesosphere and Stratosphere", Nature, 268;5622, pp. 710-711, 1977.

77-5 Klevans, E. H., G. Imel and G. N. Zinchenko, "E Region Coupling Effects on the Perkins Spread F Instability", Journal of Geophysical Research, 1977.

77-6 Nisbet, John S., Mark J. Miller and Lynn A. Carpenter, "Currents and Electric Fields in the Ionosphere Due to Field-Aligned Auroral Currents", Journal of Geophysical Research, 83:A6, pp. 2647-2657, 1978.

78-5 Olivero, J. J. and R. M. Bevilacqua, "Physical Properties Affecting the Existence of Small Ice Particles in the Mesosphere", Space Research, XIX, 1978.

78-14 Carpenter, L. A., C. A. Gonzales, M. C. Kelley and R. H. Holzworth, "Evidence for Magnetospheric Effect on Mid-Latitude Electric Fields", Journal of Geophysical Research, 83, No. A9, September 1978.

201.3 Papers Presented

Hale, L. C. and C. L. Croskey, "Electrical Structure and Ionizable Constituent Measurements", Stratcom VIII, NASA Conference, April 1978.

Mitchell, J. D., K. J. Ho, L. C. Hale, C. L. Croskey, R. O. Olsen, "Electrical Conductivity Measurements from the Stratcom VIII Experiment", Stratcom VIII, NASA Conference, April 1978.

Tomko, A. A. and A. J. Ferraro, "Electron Density Modifications in the D-region during High Power Radio Wave Heating", APS/URSI meeting, Washington, D. C., May 1978.

Mitchell, J. D., L. C. Hale, and C. L. Croskey, "Stratospheric Electrical Conductivity Measurements by Balloon-Borne Blunt Probes", paper presented at AFGL Scientific Balloon Symposium, Portsmouth, N. H., August 1978.

202 Seminars

Dr. Theordor Kostiuk, Goddard Space Flight Center, "Atmospheric Sounding by Infrared Heterodyne Spectroscopy", May 5, 1978.

Dr. S. Gonguly, Arecibo Observatory, Arecibo, Puerto Rico, "F-Region Dynamics", May 8, 1978.

Dr. P. R. Sengupta, Chief, Institute of Applied Manpower Research, New Delhi, India, "A Physical Model of the Coronal Active Regions Responsible for Enhanced $\lambda < 20$ Å X-Ray Emission", May 15, 1978.

Patrick Petruno, Ionosphere Research Laboratory, The Pennsylvania State University, "Design of a Correlator Operating at the Speeds Exceeding 100 MHz", May 26, 1978.

Dr. Marcel Nicolet, Ionosphere Research Laboratory, The Pennsylvania State University, "Chemical Aspects of the Stratospheric and Mesospheric Ozone", June 23, 1978.

Dr. Willis L. Webb, former director of the satellite program at the Atmospheric Sciences Laboratory, White Sands, Missile Range, New Mexico, "Geoelectricity", August 3, 1978.

Dr. Paul Swanson, Jet Propulsion Laboratory, Pasadena, California, "An Orbiting Sub-Millimeter Radio Observatory for the 1980's", September 25, 1978.

Dr. M. L. Heron, National Oceanic and Atmospheric Administration, Environmental Research Laboratories, Boulder, Colorado, "VHF Transequatorial Propagation Via Plasma Bubbles", September 25, 1978.

203 Visitors

Dr. P. R. Sengupta, Chief, Institute of Applied Manpower Research, New Delhi, India, April - November 1978.

Dr. Gonguly, Arecibo Observatory, Arecibo, Puerto Rico, May 5, 1978.

Dr. Theordor Kostiuk, NASA, Goddard Space Flight Center, Greenbelt, Maryland, May 5, 1978.

Dr. Richard Goldberg, NASA, Goddard Space Flight Center, Greenbelt, Maryland, May 19, 1978.

Dr. Eugenio Sanhueza, I.V.I.C., Caracas, Venezuela, July - November 1978.

Dr. Sotiris Glavas, Inorganic Chemistry Laboratory, U. of Patras, Greece, August - November 1978.

Dr. Volker Kirchhoff, INPE, Brazil, August 26, 1978.

Dr. Warren W. Berning, PSL, New Mexico University, Washington, D. C., August 29, 1978.

Dr. Paul Swanson, Jet Propulsion Laboratory, Pasadena, California, September 25, 1978.

PERSONNEL

Name	Title	Percent Funded Time	Problem
The National Aeronautics and Space Administration			
Grant NGL 39-009-003 - NASA IRL MD- 5944			
J. S. Nisbet	Prof. of Elec. Eng. Director, IRL	50.0	1.1, 1.2, 1.3
E. Bleuler	Prof. of Physics	--	1.4.1
J. Heicklen	Prof. of Chemistry	--	--
R. Simonaitis	Research Associate	--	6.1
R. Caverly	Graduate Assistant	--	
D. Glenar	Graduate Assistant	50.0	1.4
C. Li	Graduate Assistant	50.0	2.2
R. Rohrbaugh	Graduate Assistant	50.0	1.5
W. Stuper	Graduate Assistant	--	6.2
Grant NGR 39-009-032 - NASA CMMS XIII - 5901			
B. R. F. Kendall	Prof. of Physics	28.0	4.1, 4.7
Grant NAS6-2826 - NASA DART II - 5921			
L. C. Hale	Prof. of Elec. Eng.	--	3.1
Grant NSG-6004 - NASA MAP - 5956			
L. C. Hale	Prof. of Elc. Eng.	12.5	3.1
C. Croskey	Postdoctoral Scholar	33.3	5.1
Grant NSG-5212 - NASA POLAR EXPLORER - 5958			
J. S. Nisbet	Prof. of Elec. Eng. Director, IRL	--	1.1, 1.2, 1.3
M. Griffis	Graduate Assistant	50.0	
C. Stehle	Graduate Assistant	50.0	
Grant NSG-7350 - NASA PROBES - 5963			
L. C. Hale	Prof. of Elec. Eng.	4.2	3.1

Name	Title	Percent Funded Time	Problem
The National Science Foundation			
Grant ATM76-03144-A01 - NSF FOUNDATION - 6305			
J. S. Nisbet	Prof. of Elec. Eng. Director, IRL	--	1.1, 1.2, 1.3
S. Gonguly	Consultant	--	--
M. Heron	Consultant	1 day	--
T. Kostiuk	Consultant	--	--
M. Nicolet	Consultant	3 days	--
P. Sengupta	Consultant	--	--
Y. Somajajulu	Consultant	--	--
P. Stubbe	Consultant	--	--
Grant ATM76-14277-A01 - NSF D-REGION - 6224			
A. J. Ferraro	Prof. of Elec. Eng.	--	3.2
H. S. Lee	Prof. of Elec. Eng.	--	3.3
J. Breakall	Graduate Assistant	50.0	3.6
M. Sulzer	Graduate Assistant	16.7	3.4
A. Tomko	Graduate Assistant	16.7	3.5
Grant ATM76-81004-A01 - NSF PROBE FLOWS - 6656			
L. C. Hale	Prof. of Elec. Eng.	8.0	3.1
T. York	Prof. of Aerospace Engineering	12.1	--
R. Brasfield	Graduate Assistant	33.4	--
Shih-Kao Chang	Graduate Assistant	50.0	--
Huaan-Jang Tarng	Graduate Assistant	50.0	--
Chung-I Wu	Graduate Assistant	50.0	--
Grant ATM78-16832 - NSF CROSS SECTIONS - 6213			
J. S. Nisbet	Prof. of Elec. Eng. Director, IRL	--	1.1, 1.2, 1.3
R. Simonaitis	Research Associate	4.0	6.1

Name	Title	Percent Funded Time	Problem
Grant ATM77-06718 - NSF SPREAD F - 6775			
L. A. Carpenter	Asst. Prof. of Elec. Eng.	27.9	2.1
E. H. Klevans	Assoc. Prof. of Nuclear Eng.	8.0	2.3
R. Bachman	Graduate Assistant	16.7	--
J. McCowan	Graduate Assistant	50.0	--

The Office of Naval Research

Name	Title	Percent Funded Time	Problem
Grant N00014-77-C-0041 - DN INTERACTION IV - 7025			
A. J. Ferraro	Prof. of Elec. Eng.	--	3.2
H. S. Lee	Prof. of Elec. Eng.	--	3.3

Department of the Army

Name	Title	Percent Funded Time	Problem
Grant DAAG29-78-G-0083 - DA MINCON - 4500			
J. J. Olivero	Assoc. Prof. of Meteorology	49.6	1.6, 1.7
C. Croskey	Postdoctoral Scholar	25.0	5.1
R. Bevilacqua	Graduate Assistant	50.0	1.8
D. Young	Graduate Assistant	50.0	--
Grant DAA629-78-G-0129 - DA SOL - 4547			
L. C. Hale	Prof. of Elec. Eng.	2.8	3.1
C. Croskey	Postdoctoral Scholar	4.2	5.1